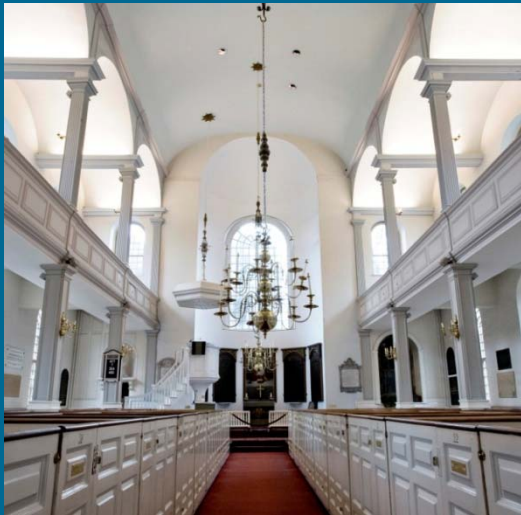


Standards & Specifications Update: Dimming & Flicker



Lightfair

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- NEMA SSL-7A contains design criteria and compliance test and measurement procedures for LED light engines and forward phase-cut dimmers
 - Published 4/22/2013
- EPA ENERGYSTAR is working on dimming criteria for Lamps
 - Draft 4 Version 1.0, published 4/19/2013
- California Code of Regulations, Title 20, Public Utilities and Energy does not contain any dimming criteria
 - CEC-140-2012-002, published November 2012
- Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification contains some dimming criteria
 - CEC-400-2012-016-SF, published December 2012

- IES Testing Procedures Committee Working Group S408-10 is poised to form a committee in May to work on a test method for optical waveforms
- EPA ENERGYSTAR is working on flicker criteria for Lamps
 - Draft 4 Version 1.0, published 4/19/2013
- California Code of Regulations, Title 20, Public Utilities and Energy does not contain any flicker criteria
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Inception of NEMA SSL-7

- Market demand by lamp and control manufacturers and sales channels
- Demand from industry forces



U.S. DEPARTMENT OF
ENERGY



Z Zhaga

- Work by other standards bodies



- Frustrating user experiences



- Release of NEMA SSL-6 in 2010
 - Described installed base of phase-cut dimmers
 - Latent realization that variation in installed base was difficult to design for
- Formation of NEMA SSL-7 committee in late 2011
 - NEMA Lighting Section members
 - European manufacturers, IC manufactures (invited through Zhaga)
 - UL, DOE
- Adoption of a forward-looking strategy to bound the problem
 - Don't address *existing* products
 - Do provide design criteria for *new* products
 - Do target global scope (100, 120, 230, 277V operation)

- An interface standard that addresses the interaction between dimmers and LED light engines



- Design criteria for both dimmers and LED light engines
- Test & measurement procedures for verifying that both dimmers and LED light engines meet the specified design criteria
- Acceptance wholly or in part by standards bodies (Zhaga, UL, IEC, etc.) and adoption agents (EPA ENERGYSTAR, California Energy Commission, etc.)

- The problem is very complicated! A decision was made to focus on a single type of phase control, and separate issues and technical challenges into two areas.

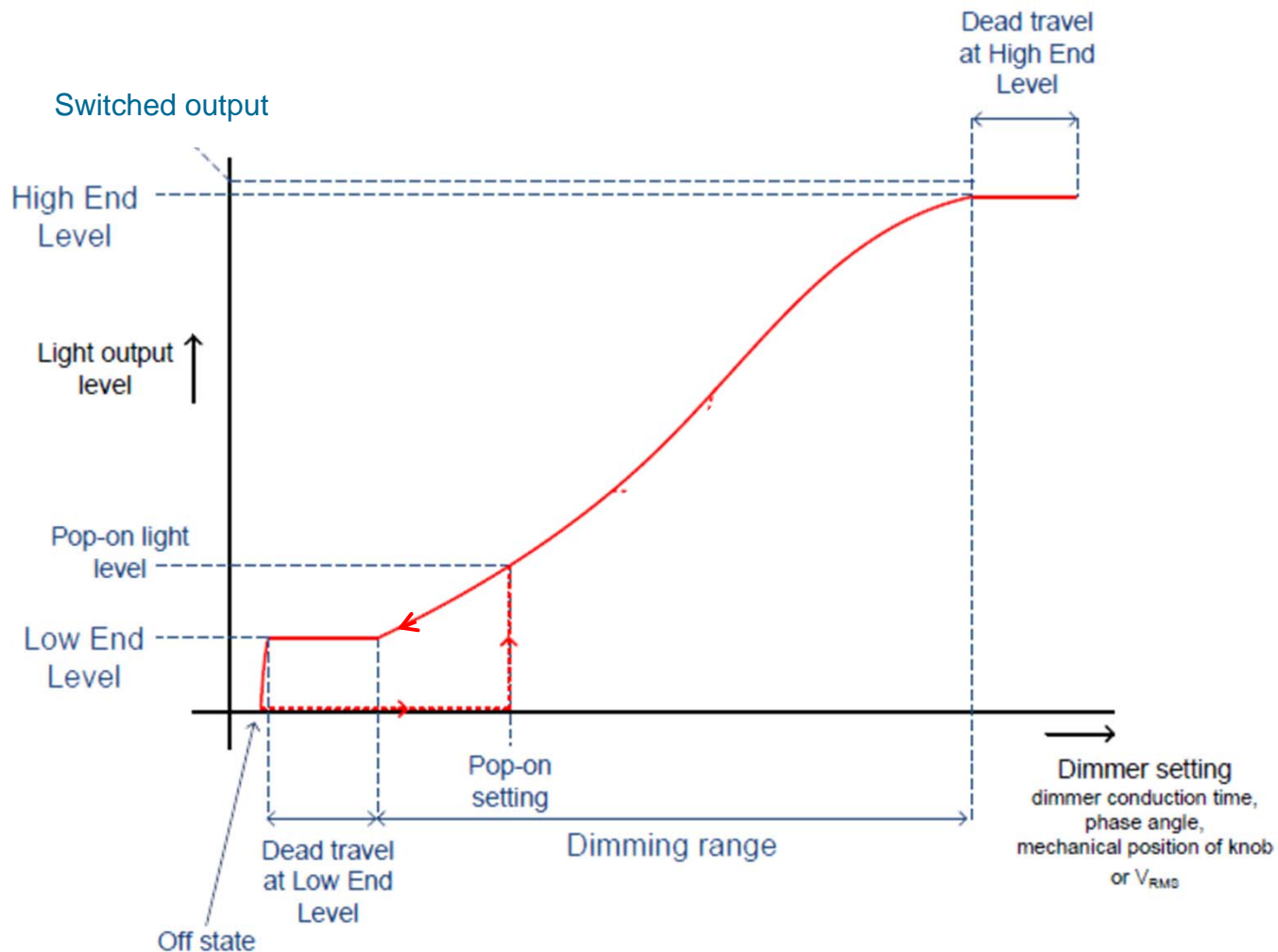


- NEMA SSL-7A will address Compatibility for forward phase-cut dimmers and LED light engines; a potential future extension or new document may address Performance
- Compatibility (or Interoperability)
 - Dimming behavior meets or exceeds specified functionality
 - Reliability of the dimmer and light source are not affected by combining them

Poor User Experiences

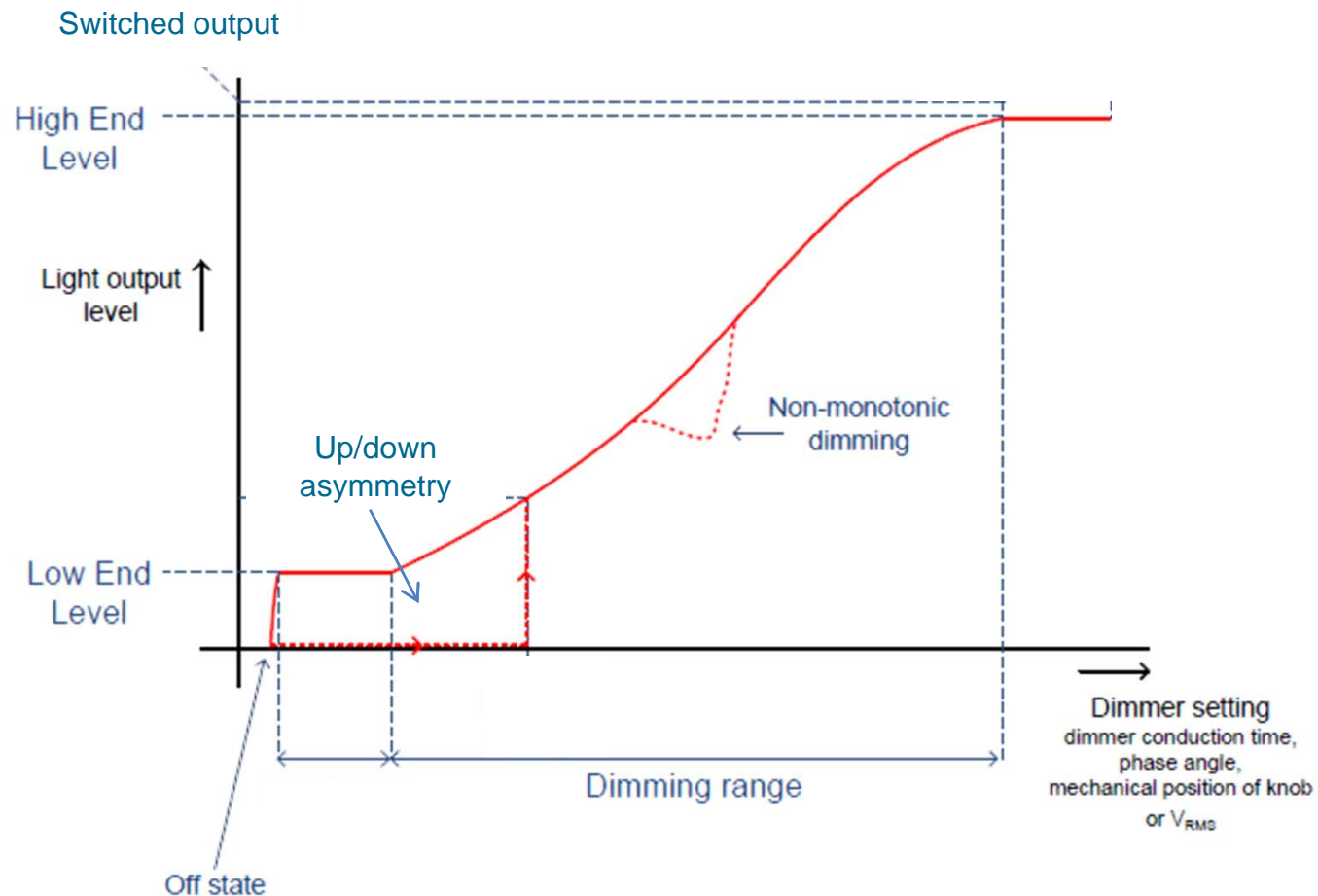
- ☐ Dimming range
- ☐ Dead travel
- ☐ Pop-on
- ☐ Drop-out
- ☐ Popcorn
- ☐ Ghosting
- ☐ Flashing/Strobing
- ☐ Induced Flicker
- ☐ Audible noise
- ☐ Dimming smoothness
- ☐ Dimming monotonicity
- ☐ Dimming up/down symmetry
- ☐ Dimmer loading
- ☐ Dimmer - LED light engine inoperability
- ☐ Premature failure of dimmer and/or LED light engine

Dimming range, dead travel, pop-on



Source: Modified from NEMA SSL-6

Dimming smoothness, monotonicity, up/down symmetry



Source: Modified from NEMA SSL-6

Technical challenges

- ☐ LED load RMS current
- ☐ LED load inrush current
- ☐ LED load repetitive peak current
- ☐ Repetitive ring-up voltage
- ☐ Dimmer switching element current requirements
- ☐ Dimmer timing element series impedance requirements
- ☐ Dimmer on-state and/or off-state operating current requirements

What does NEMA SSL-7A achieve?

Poor User Experiences

- ✓ Dimming range
- ✓ Dead travel
- ✓ Pop-on
- ✓ Drop-out
- Popcorn
- ✓ Ghosting
- Flashing/Strobing
- ✗ Induced Flicker
- ✗ Audible noise

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- Dimmer - LED light engine inoperability
- ✓ Premature failure of dimmer and/or LED light engine

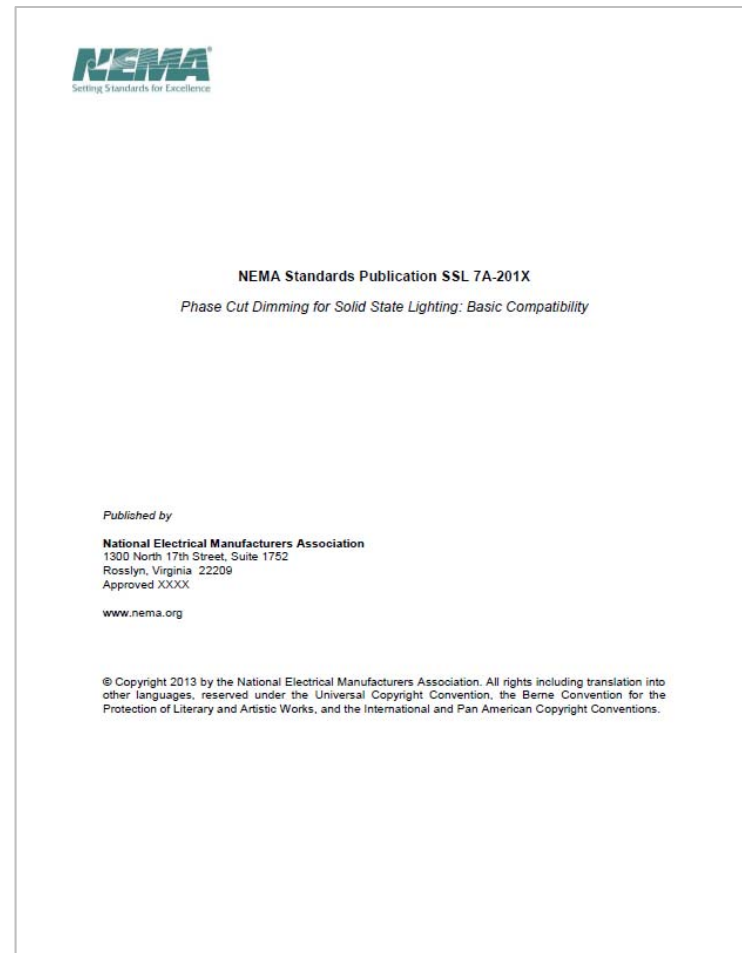
What does NEMA SSL-7A achieve?

Technical Challenges

- ✓ LED load RMS current
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- Dimmer switching element current requirements
- ✓ Dimmer timing element series impedance requirements
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What comes next?

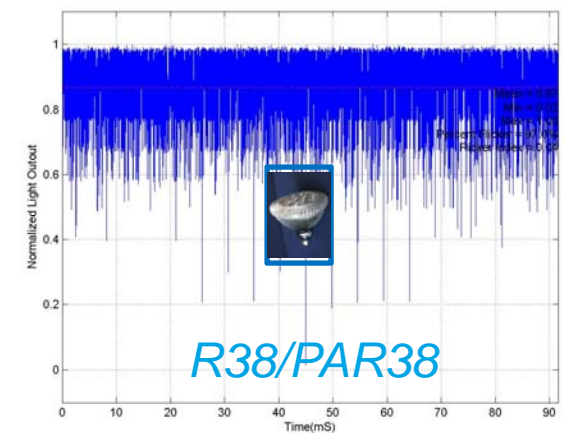
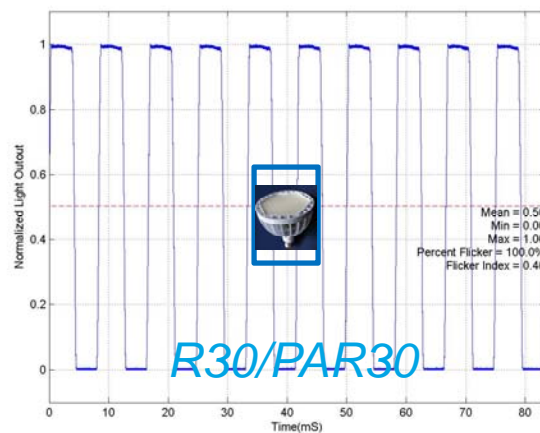
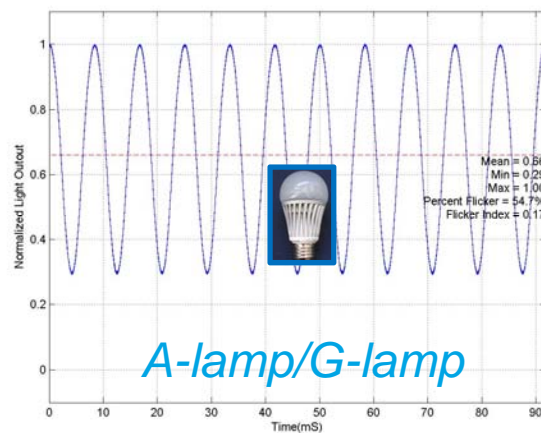
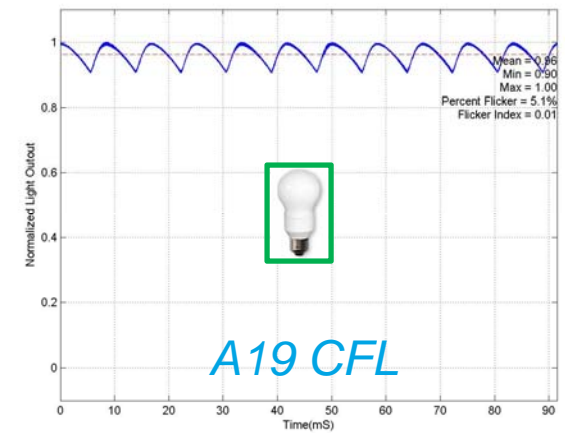
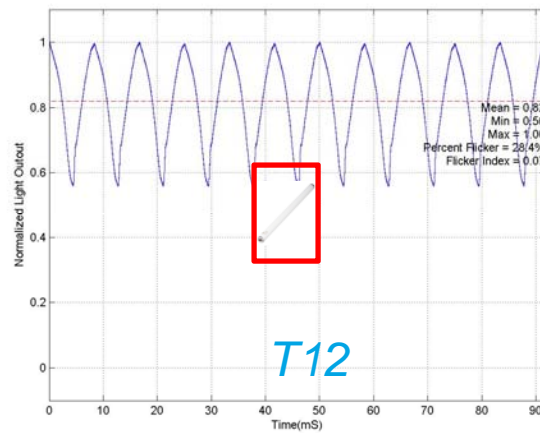
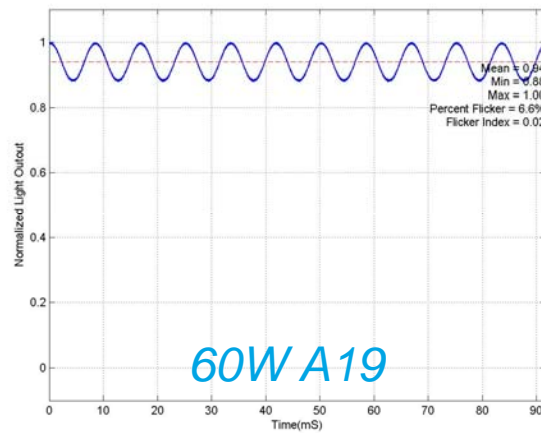
- Publication
- Commercial adoption
 - SSL-7A compliant products
 - Product labeling guidelines
 - End-user education
- Adoption by standards bodies
- Influence of specification agents
 - Zhaga
 - EPA ENERGYSTAR
 - California Energy Commission



Commercial adoption



Flicker issues



- All traditional light sources flicker, but unprecedented flicker characteristics can be found in commercially available LED sources
- Significant potential human health impacts, including various neurological problems (including epileptic seizure), headaches, fatigue, blurred vision, eyestrain, reduced visual task performance, stroboscopic and phantom array effects, and distraction
- Not all flicker claims are equal
 - Metrics exist, but are not widely used, and do not account for frequency.
 - No standard measurement procedure
- Potential impacts of flicker have population and lighting application dependencies – requiring risk analysis

- NEMA SSL-7A
 - Poised to significantly improve user experiences, but only for combinations of compliant LED light engines and forward phase-cut dimmers
 - Manufacture adoption should be high, and compliant products available soon. Achievement of goals, impact of limitations, required refinements to achieve robustness TBD
- EPA ENERGYSTAR
 - Not currently considering requiring SSL-7A compliance
 - Flicker requirements could significantly improve commercial lamp evaluation for flicker, but (currently) only apply to dimmable lamps
- California Energy Commission
 - Title 20 likely to have flicker requirements in the future
- CIE TC 1-83 may begin working on Visual Aspects of Time-Modulated Lighting Systems

- Dimming evaluation of SSL-7A compliant LED light engines and dimming controls
 - Focused on verifying compatibility/interoperability goals
 - TBD, depending on when compliant products become available
- Flicker fact sheet
 - Published March 2013
 - http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/flicker_fact-sheet.pdf
- Recommendations for Flicker Criteria
 - Multiple options, presented in context of existing research and commercial product performance
 - Focused on capabilities, limitations, and trade-offs
 - Coming soon

Flicker criteria proposal(s)

*Potential criteria presented and discussed at CIE
Centenary Conference, Paris, April 2013*

